

March 17, 2004

Dr. Andrew Christensen, Chair  
Space Science Advisory Committee

Dear Andy,

The Structure and Evolution of the Universe Subcommittee (SEUS) met in public session at the Inn and Conference Center of the University of Maryland on 24-25 February 2004. About half of the time was spent in joint session with the Origins Subcommittee (OS). All current members of the SEUS were present except for Dr. Joel Bregman. As you know, all material presented to the subcommittee may be found on the SEUS website: <http://spacescience.nasa.gov/admin/divisions/sz/SEUS0402/>.

### **SEU THEME AND BEYOND EINSTEIN UPDATE**

The SEUS received an update from Dr. Paul Hertz, Theme Scientist, who gave a thematic overview of the budget and other Structure and Evolution of the Universe (SEU) matters. Dr. Anne Kinney, Director of the Astronomy and Physics (A&P) Division, presented an overview of A&P activities. Dr. Ed Weiler, Associate Administrator, discoursed on Space Science in the context of the President's Renewed Spirit of Discovery.

The newly announced Presidential vision would have a huge impact on SEU. The proposed FY05 budget supports the President's vision for space exploration. The space-science budget will increase by 4% in the coming year and 40% over four years. Four space-science themes are considered part of the exploration budget: Astronomical Search for Origins, Solar System Exploration, Mars Exploration, and Lunar Exploration. Structure and Evolution of the Universe is not part of the exploration vision.

As a result, the SEU budget outlook is grim. There have been delays in LISA and Constellation-X, the two strategic missions of Beyond Einstein, and elimination of any funding for Einstein Probes for at least 5 years. The only bright spot is that some additional funds have been made available for Gravity Probe B (GP-B), the Gamma-ray Large Area Space Telescope (GLAST), and Swift. Also, Research and Analysis (R&A) and Chandra have not been impacted adversely during FY04-FY05, remaining roughly the same, with a small inflationary increase (1%) for R&A. Five-year budget projections indicate minor decreases in the near-term, with a late upturn to support the Laser Interferometer Space Antenna (LISA) launch.

The reduction in the FY05-09 budget requires serious replanning. For LISA, NASA must slow down planned work to match the budget and to identify resource mismatches with ESA. Con-X has had a significant budget decrease. An opportunity has arisen to internationalize Con-X as a means of realizing the mission more quickly and discussions will begin with potential international partners to address this issue. The Einstein Probe mission concept studies are moving forward, as the science is still compelling and should continue to be advocated. The Beyond Einstein (BE) Education/Public Outreach (E/PO) will continue with a concentration on LISA in the near term.

*The science goals of Beyond Einstein--- probing the edge of time at the big bang, the edge of spacetime in black holes, and the mysterious dark energy accelerating the expansion of the universe, are among the most exciting topics in all of science today. The consensus of experts validates the primacy of these goals, as expressed in several reports of the National Academy of Sciences and the strategic plans of both NASA's Space Science Enterprise Roadmap, the DOE in the High Energy Physics HEPAP Bagger-Barish report, as well as the DOE Office of Science Facilities Plan. The Beyond Einstein initiative explores some of humanity's deepest questions about the beginnings and ends of all of space and time. For the first time these questions can be answered, using tools and technologies of space science that only NASA can command.*

*These are missions that should be done, not because of the Exploration Initiative, and not despite the Exploration Initiative. They should be done because they will answer profound questions about the origin of the universe in the big bang, the destiny of the universe as determined by dark energy, and the fundamental nature of space and time as probed near the horizon of a black hole. We recommend that these programs be restored to the highest priority, reflecting their scientific importance and NASA's unique role.*

*We applaud the significant strides already taken in Beyond Einstein, including mission concept studies, and the remarkable technical advances in both LISA and Constellation-X. We suggest that progress on LISA and Constellation-X, the flagship missions of Beyond Einstein, be accelerated as much as possible. We unanimously endorse Einstein Probes as a top priority to receive new funding. JDEM requires particular attention because of its synergy with DOE strategic plans. We endorse the immediate formation of a JDEM Science Definition Team to solidify a consensus among the science community on instrument science requirements.*

## **EDUCATION AND PUBLIC OUTREACH**

SEUS heard reports on an impressive variety of SEU E/PO activities by the SEU Forum and the Beyond Einstein office. Mr. Roy Gould, Director of the SEU Forum, presented some take-home messages on SEU E/PO activities. There is very strong public interest in the SEU theme, as evidenced by presented quotations from participants in recent E/PO programs, and the Einstein centennial will provide further leverage to build on this interest. The goal is to reach a diverse audience in the pre-college population, and to supplement the dearth of astronomical knowledge possessed by elementary school Earth-science teachers. The Cosmic Questions National Exhibition is on tour through at least 2005, and it is a showcase for SEU science. It will have attracted 1 million visitors after its current venue. The SEU Forum has redone its website to reflect its focus on the Beyond Einstein theme. There is also an opportunity to reach the many amateur astronomers in the US, who typically do not have a strong interest in SEU science. The limiting factor in the classroom teaching of Big Bang theory is lack of professional development. Student interest in Big Bang cosmology is identified as high. Priorities are

to develop the SEU story and unify with the other science themes, and provide students with better tools for study.

Mr. Paul DeMinco, SEU Theme Manager at GSFC, presented a summary of planning for E/PO in the BE program. The results of an external review of OSS education programs provided a starting point for analysis. The review suggested that teachers have trouble getting the data they need to present BE concepts. The science message rather than the mission must be the obvious focus. There are also challenges peculiar to teaching BE physics that need to be addressed. A Framework Initiative has been undertaken to identify issues by grade level (K-12). The AAAS has a project 2061 Atlas that reflects the desired ideas that would be expected in 2061. The Atlas is weak in presenting SEU science and there is an opportunity to rectify this. A Fall 2003 workshop identified middle and high school science as good targets. National science standards are not followed consistently among states. The OSS Framework will provide guidelines to deal with this inconsistency. Another target of opportunity is the two-year college, because many teachers begin their education there. There is a potential to collaborate with the National Science Teacher's Association and the National Council of Teachers in Mathematics in DC. Current initiatives with DOE include creation of a sustained collaboration in both the education and public outreach area. A science symposium to celebrate the Einstein centennial is under consideration. The theme is also collaborating with the American Association of Physics Teachers (AAPT) and NASA's Navigator Program, leveraging existing efforts with community colleges and the AAPT. A new tool in outreach includes high-definition animation. Future activities are additional workshops, and development of a long-term plan that flows with the results of the Framework Initiative and the availability of funding.

*Noticeably absent, however, was a close connection with specific SEU programs and missions. We sense that there is a lack of coordination, overview, and overarching goals. What is the purpose of SEU's E/PO activity? Is it to excite a new generation of scientists, to generate public support, or to improve science education? In particular, how do the various activities further these goals? It is, we recognize, a challenging task to tie together and coordinate all these diverse activities. Nevertheless, it might make sense for either the SEU Forum or the Beyond Einstein office to take on the responsibility of coordinating SEU E/PO activities. There is a near-term opportunity for highlighting SEU's activities via the Einstein Centennial, and we would appreciate hearing by the summer about ideas for capitalizing on this opportunity and tying SEU's E/PO activities together.*

### **BALLOONS AND SOUNDING ROCKETS**

Dr. Vernon Jones presented an update on the balloon program, which provides low-cost access to space at an altitude of 120K feet, and niche science investigations that can be done above 99.5% of the atmosphere. The program also makes possible observatory-class payloads with advanced technologies and large aperture mass, technology development and flight validation for future space missions, and cutting edge science in 10-20 day missions. The program must increase its flight rate; it has been decreasing linearly over

the past 4 decades, although flight durations have been increasing. There is insufficient funding for building payloads and for operations. 40M-cubic-foot balloons were introduced in 2004. The ANITA experiment for neutrino-based observations was described. The program is at a crossroads. Changes since the Columbia accident justify a new plan for balloons. The plan is to focus a strategic balloon plan on both payloads and operations, increase the number of conventional and long-duration balloon (LDB) flights, and complete the development and demonstration of ultra-long duration balloon flights (ULDB). "Big 60" flights will enable UV observations. Flights in Antarctica are limited by an insufficient NASA budget, inadequate logistics support from the NSF/Office of Polar Programs for more than 2 flights per year, inherent limitation of austral summer length, the need to recover balloon carcasses to meet EPA constraints, and self-imposed limitations due to operations policy. Additional resources are needed from NASA/OSS. A modest budget line could double or triple the LDB flight rate. More logistics support is needed from NSF/OPP. Resources are also needed to improve the recovery process, such as an additional aircraft. Procedural changes in operations could increase efficiency. One option is to let balloons "fly till they die" if recovery is not required for a follow-on science flight, (but there may be environmental concerns for this option). The strategic planning process is under way, with an Antarctica workshop planned for May 2004. The critical question is: Is there sufficient quality science available for justifying new payloads?

Plans for the ULDB Program Recovery were presented by David Gregory, Assistant Chief, Balloon Program Office. After a failure to deploy and maintain pressure of a balloon during a test flight at Alice Springs in 2003, some modifications in the design and fabric process have been made, including strengthening tendons that bear the load. Five test flights will be conducted this year. A 6 million cubic foot (MCF) balloon will be taken to Australia in December 2004, with a 21 MCF balloon to be flown in December 2005. Other studies are ongoing to mitigate clefting problems with balloon materials. Antarctica balloon operations were briefly touched on. A new facility is planned for completion by October 2005, with a two-payload (perhaps three) support capability. A new launch vehicle has also been introduced.

Dr. Philippe Crane introduced a briefing on the sounding rocket program, an important part of the R&A program. Almost all flying satellites have detectors that were built and flown either in the sounding rocket or the balloon programs. Dr. Mary Mellott, Sounding Rocket Program Scientist, announced that a significant new capability at Wallops can be developed in very high-altitude, long hang-time rockets. The new budget has adversely impacted the development of this new capability in sounding rockets. Dr. Mellott asked for SEUS advice on rebalancing the budget to support the High-Altitude Sounding Rocket (HASR) program on its intrinsic merits. Dr. Philip Eberspacher continued the presentation. The sounding rocket program offers unique opportunities for low-cost, fast-turnaround, focused scientific research, platforms in space for testing and developing new technology, and hands-on training for young researchers. A typical flight profile is about 700 km altitude and 1000 km range. Vehicles include the Terrier Malemute, Nike Orion, Terrier Orion, and Black Brants IX and XI. Experiments span the disciplines from astronomy through plasma physics, air sampling, and atmospheric entry vehicles. The program leverages multiple sources (e.g., Navy) for funding. The HASR is the next generation rocket, providing a 1000-lb total payload (700-lb science instrument),

50-inch fairing, 3400-km apogee, and 40-minute observation time. The cost per mission was estimated at \$5M or less per vehicle, plus operations (\$10M total). A tentative plan was to launch one HASR every one or two years while maintaining the smaller rocket program. This plan is not supported by new budget projections.

***The SEUS applauds the effort to integrate the goals of the balloon program into the overall strategic planning process. In this context, we request a presentation at our November meeting that would supply a crisp case for this program as it pertains to the upcoming revision of the SEU Roadmap. We thank NASA for maintaining the viability of the balloon capability so that it can be incorporated into the Roadmap. Finally, we look forward to hearing about a successful demonstration of the Ultra Long Duration Balloon capability at a future meeting.***

***We recognize the rocket program as a valuable resource in training the next generation of scientists and engineers, and in testing new detector technologies for space flight. However, we would like to have additional information in the following areas:***

- 1. What is the specific role of the rocket program in supporting the development of technologies for future SEU missions and in producing SEU science?***
- 2. What are the criteria that are used to evaluate the strategic role of the rocket program?***
- 3. How would the new HASR change the number of launches per year? How would priorities to use the HASR be traded off vs. a larger number of smaller rocket launches?***
- 4. What SEU science would be enabled by the proposed HASR vs. smaller rockets and vs. balloon payloads?***

## **RESEARCH AND ANALYSIS PROGRAM**

Dr. Jeffrey Hayes provided an update on R&A activities, including Theory, GO and Archives. Traditional elements of the program are ultraviolet (UV)/optical detectors, infrared (IR) submillimeter, origins of solar systems, high-energy astrophysics, balloons, sounding rockets. Data analysis and theory elements include ADP/LTSA, ATP, and BE Foundation Science (BEFS). BEFS contains all elements, not just Theory. The ROSS schedule deadlines were presented. Delayed grant notifications in OS/SS have been due to budget uncertainties and understaffing problems. The A&P policy for GO funding programs is to support users of NASA assets in the analysis of their data- the mission set includes HST, Spitzer, and Chandra. FY04 funding levels for various continuing and new awards were presented. The total is \$164M for FY04. Senior Review guidance largely determines the distribution of dollars and the quality of the proposals. There is some flexibility to rebalance the distribution once the budget is in place in response to quality of proposals as determined by peer review. Operations are not part of this budget; it also does not include legacy teams. A&P has responded to calls for more Theory support, and added new funding to HST, CXO, SST, and BE (about \$13M, in full-cost accounting dollars). This represents a significant increase in Theory funding. In addition, there are other sources of Theory funding scattered throughout OS and SEU. Skepticism was

expressed about the full amount of funding, impacted in part by the costs for NASA civil servants. The quality of the grants (in terms of proportion one-year versus three-year grants) was debated. The Decadal Survey recommendation was to associate Theory programs with missions at appropriate stages of development, and NASA has answered this recommendation (e.g., in early BE and TPF). A breakdown of funding was presented. FY04 funding levels for the Archives is about \$25M. The community does not fully understand that Theory is distributed so broadly among programs. ROSS has been rewritten to deal with this question- it includes an explicit but conservative representation of new monies available each year. Dr. Richstone remarked that Theory has been rated so highly because Theory papers have been giving extraordinary bang for the buck, in extending the value of missions and providing a pathway for future missions.

*The R&A program supports NASA's strategic plan through research and data analysis, theoretical studies, and guest observer programs. Continued support of R&A is vital to a healthy science program, and we applaud the increased ATP and mission-related theory support. This satisfies a concern of the 2000 Decadal Survey to increase funding for astrophysical theory, and we encourage continued support for Beyond Einstein Foundation Science. The Subcommittee expressed an interest, however, to understand the reasons for the differences between analysis funding for the different Great Observatory programs, e.g., we would like to understand the mismatch between Chandra, HST, and Spitzer.*

## HST

The SEUS was briefed on the decision to cancel the Hubble Space Telescope servicing mission SM4.

*We note that the Hubble Space Telescope has in the past made key contributions to SEU science and we are very concerned by the loss of the future unique and compelling SEU science which would have been enabled by SM4. We commend and endorse the efforts which are being undertaken to extend the Hubble Space Telescope's operational life without additional servicing and to maximize the mission's science return. We encourage NASA to continue to explore options and alternatives to recover this regrettable loss of science.*

## TECHNOLOGY PLANNING

Dr. Melvin Montemerlo presented the results of a request for a listing of enabling technologies for Code S/Z, and technology development strategies. The documents are the *A&P Technology Development Strategies*, and the *A&P Enabling Technologies For Future Missions/SEU and OS Themes* (both distributed). These surveys should help the roadmappers take the technology requirements into account as planning progresses. These documents will not be discriminators for selection. The technologies called out will be high priority, but technologies not included will not be rejected out of hand. It is

intended to be a helpful document and not a limiting or threatening document. The Spacecraft Technology Program History (began as Code R) was briefly reviewed, noting that changes in Code identification have been numerous. Dr. Montemerlo requested feedback from OS and SEUS on the accuracy and utility of the survey results.

The newly formulated Code T plans include a contractor review of all Code R Space Technology tasks in early March 2004. Code T will then determine what to continue- the timing of this decision is not known. For the first time, the technology program is in an Office that is responsible for its own projects, including vehicles and missions. Code T is not an Institutional Program Office and does not have responsibility for Centers. Boundaries have not yet been defined. Code S and T have divided responsibilities for the lunar mission, for instance. Restructuring is important for long-term science; these concerns should be taken to the NAC.

*Committee members endorsed the survey effort and encouraged Dr. Montemerlo to consider information technology/software needs.*

*The SEUS was pleased by the systematic approach to identifying the technology needs of Astronomy & Physics missions shown by the draft "Enabling Technologies..." report presented by Mel Montemerlo.*

*Detectors, coolers, low mass optics, vibration-free structures and precision formation flying are required for future A&P missions and need to be developed to enable progress in space science.*

*The SEUS would like an update about the interface between Code S and the new Code T technology development program under the new organizational structure.*

### **AAAC REPORT**

Dr. Hertz presented a synopsis report from the AAAC, a joint NASA/NSF advisory committee on astronomy. Robert Gehrz is the outgoing Chair and Garth Illingworth is the Chair-elect. AAAC endorsed JWST, expressed concern for BE and had a lively debate about SM-4. AAAC also endorsed the astronomy and astrophysics supported activities in the DOE Office of High Energy Physics. An x-ray astronomer was suggested for the AAAC. There may be a need for a gravitational wave scientist, however, as there are overlaps between NSF and NASA in this area. The AAAC does implicitly endorse the Inflation Probe because of its support for the future of CMB research roadmap. The SM-4 discussion is still under way, but the AAAC is expected to point out the science losses incurred by the loss of the mission.

### **SAWG REPORT**

There were no comments. The report is available on the Web. A copy is attached.

### **OTHER PRESENTATIONS**

Dr. Harvey Tananbaum, Director of the Chandra X-Ray Center, presented recent science results from Chandra. SEUS would like to thank Dr. Tananbaum for the excellent presentation and congratulates him and the Chandra team for the continued success of the mission.

Dr. Bryant Cramer, LISA Project Manager, presented an update on the status of the LISA mission. Program Manager Dr. Elizabeth Citrin presented an update on Constellation-X (Con-X). SEUS recognizes substantial progress on both LISA and Con-X in spite of budget problems.

Respectively submitted on behalf of the SEUS,

Rocky Kolb